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Electrical Engineering/Junior

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Fall 2011

Purpose: Inform reader of cooperative education experience at the National Aeronautics and Space Administration (NASA) Johnson Space Center (JSC).

Objective: Obtain practical working experience in the electrical engineering field.

History:

The NASA was founded in 1958 by President Dwight Eisenhower. NASA was created largely because of concern over the Soviet Union's formation of a space program. Since then, NASA has collaboratively worked with international partners and accomplished many scientific and technological achievements. Many of those achievements have been adapted for use in the private sector.

There are 11 NASA Space Centers across the United States which employ nearly 19,000 federal workers. The Lyndon B. Johnson Space Center (JSC) has the largest federal workforce of all the NASA Space Centers. JSC was established in 1961 and was formerly known as the Manned Spacecraft

Center. Today JSC consists of over 100 buildings covering over 1600 acres of land. The land upon which JSC was built was donated by Rice University. JSC's primary role within the agency is to provide spaceflight training for astronauts, flight control during missions, and to research and develop innovative technologies.



Figure 1: Aerial view of the NASA Johnson Space Center.

The Avionic Systems Division is a division of the Engineering Directorate at JSC. Within the Avionic Systems Division, the Human Interfaces Branch (EV3) is the office of primary responsibility for all avionics systems that a crew member uses. The avionics systems which EV3 provide technical expertise for include imagery, audio, and displays and controls systems.

Work Assignments:

My primary tasks for my second tour here at JSC were working with an Augmented Reality Project and also constructing a Dodecahedron Speaker. I was mentored by several people during this tour including Mary McCabe, Andy Romero, and George Salazar. While working on these two projects, I was able to gain a great deal of hands-on electrical and programming experience.

Augmented Reality Project:

My first task was to familiarize myself with and modify enhance voice recognition software. The software developed for this project was primarily worked by a summer intern. The previous intern was able to successfully program a VoiceGP Development Kit Module which would respond to voice commands and playback an In-flight Maintenance (IFM) procedure. The program was coded using the C programming language. I had very little experience programming prior to this tour. The first challenge I faced was debugging the previously developed program, getting the program back to its original state and demoing the software. I

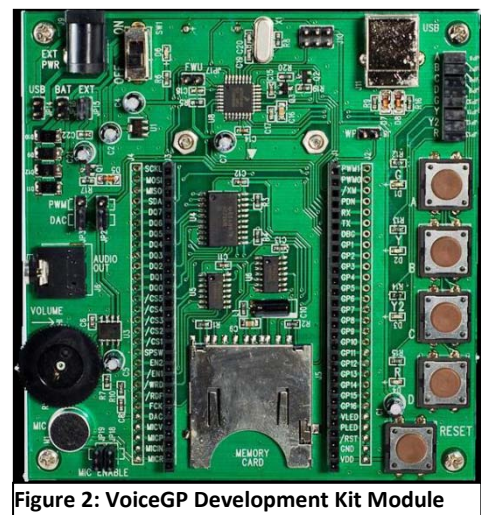


Figure 2: VoiceGP Development Kit Module

was given many reading materials to gain a better understanding of the C programming language. After some time spent troubleshooting and gaining an understanding of the program, I

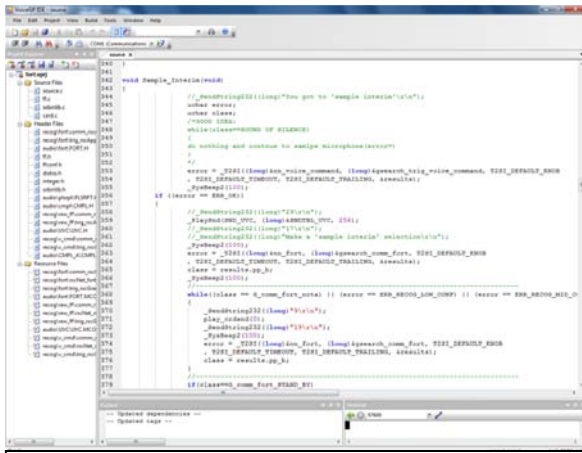


Figure 3: Voice Recognition Program

was able to determine that there were two misplaced closing brackets nested in the code.

After realigning the brackets throughout the code,

I was able to make modifications within the code

which included providing a more structured

program and incorporating an audio ON/OFF

voice command for user preference of actively

listening to the IFM procedure. It was also desired to have a microphone jack added to the board to allow for the use of a noise cancelling headset. Soldering the microphone jack to the PC board and identifying the proper connections which needed to be made were new experiences for me, however I was able to successfully add the microphone jack to the PC board.

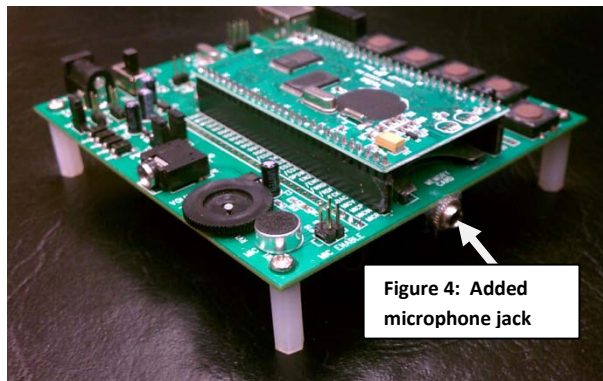


Figure 4: Added microphone jack

The next aspect of the project was to accomplish computer mediated reality with a pair of augmented reality goggles manufactured by Vuzix. My objectives were to first perform object recognition by using NI Vision Software and then have the software project a two-dimensional text overlay or animation onto the display of the goggles. The text overlays or animations could

then serve as a visual aid to complete a procedure as key objects are referenced. I was unable to accomplish as much as I would have liked with respect to this portion of the project due to issues with procuring the NI Vision Software as well as the 2nd generation augmented reality goggles. I was able to successfully interface the goggles with the NI Vision Software, however soon after that feat, a hardware issue I discovered with the camera on the goggles required shipping them back to the manufacturer for repair. Before shipping the goggles back to the manufacturer, I was also able to make presentations to the JSC Engineering Director, Steve Altemus as well as other co-op students interested in the EV Division. I also worked on preparing a detailed summary of



Figure 5: Vuzix AR920 Goggles (Left) Vuzix Star1200 (Right).

the work I completed & assisted David Overland with transitioning in to take over the project.

Dodecahedron Speaker Project:

The purpose of the dodecahedron speaker is to provide an omni-directional sound source which can then be used to acoustically stimulate a habitable volume. Acoustic modeling of the volume can then be performed to determine optimum placement, quantity, frequency response and power requirements of loudspeakers and microphones. The primary reason the

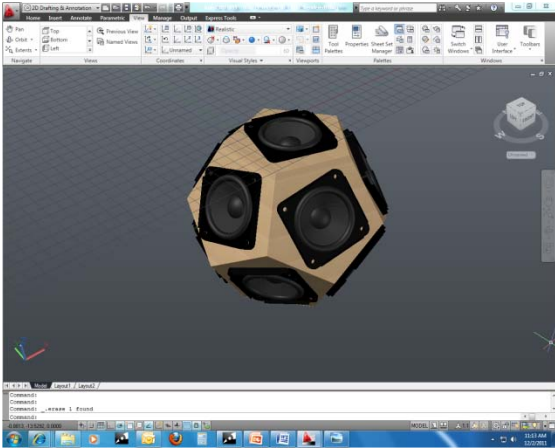


Figure 6: Finished 3D model of dodecahedron speaker.

dodecahedron shape was selected is because it allows for a uniform spherical distribution of an audio signal. It is possible that a geometric solid with more faces could be used, however a dodecahedron shape was deemed to be sufficient.

I was able to learn a great deal about the design, manufacturing, and assembly process during the

project.

My mentor Andy Romero first asked that I use AutoCad software to model the dodecahedron speaker. This required understanding the dodecahedron shape itself. The dodecahedron is a geometric solid with 12 pentagonal faces. In order to construct an accurate 3D model of the dodecahedron, the angles at which the faces were joined had to be precise. This proved to be more challenging than I expected, however I was able to finally draw a solid 3D model. It was then brought to my attention that we would be using 1/2" thick plywood as the housing material for the speaker. I decided to then model one of the 12 speakers we planned on using for the dodecahedron speaker to scale. This would serve as a method of determining the size of each of the pentagonal faces we would manufacture. After successfully modeling the dodecahedron speaker in AutoCad, I set forth to design the amplifier circuit.

I decided to use a TDA7385 car radio amplifier chip to drive the speakers. The

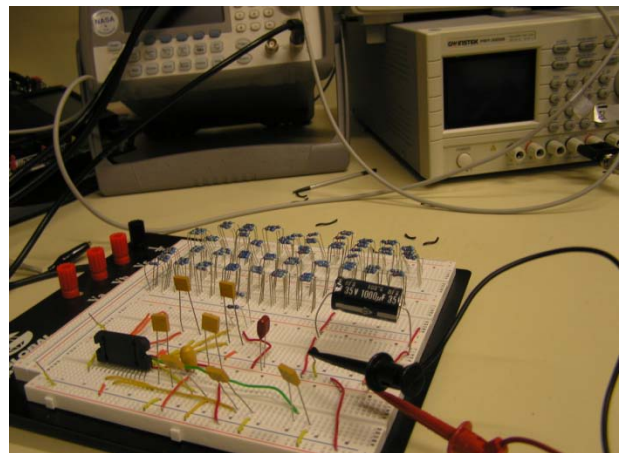


Figure 7: Breadboarded amplifier circuit.

TDA7385 chip has four channel outputs and is capable of providing 35 watts of power to each speaker. After acquiring the amplifier chips, my mentor requested that I breadboard the amplifier chips in the audio lab to ensure we understood the circuitry we planned on using as well as the performance of the amplifier chip. The chip is manufactured by STMicroelectronics and the company provides a suggested circuit schematic with the datasheet for the component. After obtaining the various capacitors and resistors recommended in the datasheet, I started to make the connections as shown in the circuit (see Figure 7). It took a significant amount of time troubleshooting with a function generator, a multi-meter, and an oscilloscope before I was able to finally produce a functioning circuit.

I was then advised I should begin capturing the circuit schematic using the software tool Altium. I had never worked with Altium before and discovered that there was a significant learning curve associated with the software. After receiving many tips and guidance from Andy Romero, Fred Shetz, and Richard Norman, I was able to make progress with the software tool. The process of completing the circuit schematic also included having to manually add specific components to a custom library. My first version of the circuit schematic in Altium (see Figure 8), although wired accurately, was not user friendly and was difficult to follow. I then discovered the usefulness of “net ports” which allow you to make connections without having to

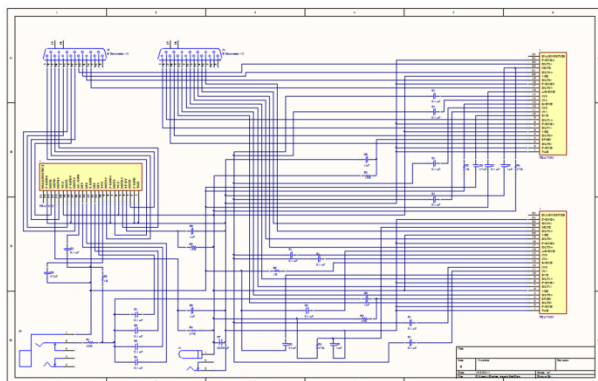


Figure 8: First version of circuit schematic using Altium software.

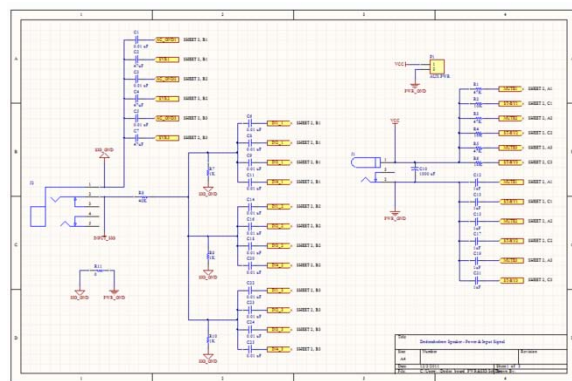


Figure 9: Second version using net ports for more organized schematic.

manually wire the components in the software. This allowed for the same circuit schematic to be represented in a more neat and organized fashion (see Figure 9).

After completing the circuit schematic, I then proceeded to design the printed circuit board which was also done using the Altium software. I had no prior experience with PC board design, so this was another great learning opportunity. There were many things which I needed to keep in mind while generating the PC board layout such as trace width, the size of the PC board, and proper clearances between the components. I also had to produce custom footprints for many of the components I decided to use. This was done to ensure that the components would fit on the board after the PC board was fabricated. After producing a few different versions of the PC board layout, I was eventually able to select the best one to have fabricated. I decided it would be faster to have the PC board fabricated in house and this also gave me the opportunity to observe the fabrication process.

Although the process of fabricating a PC board is very tedious and methodical, it did not take longer than one complete working day for the technician to finish.

After the PC board was completed, I then moved on towards constructing the housing for the

speaker. This was definitely one of the more challenging phases of the project due to there being a lack of information about how to actually construct the geometric solid. During this time I had an opportunity to take advantage of a newly opened facility at JSC called the Innovation Design Center (IDC). At the IDC, there are various hand & power tools that engineers at NASA are able to use for prototyping just any ideas that they are interested in. It is especially useful for students working at JSC because we typically do not produce any flight graded hardware and therefore

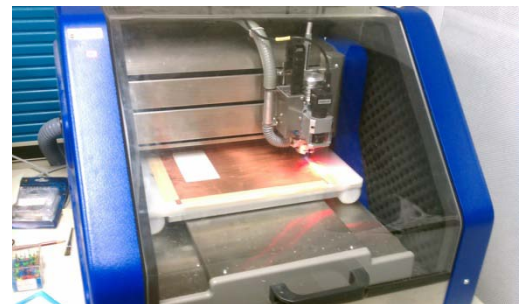


Figure 10: PC being fabricated.

are encouraged to use the facility. Before using any of the equipment at the IDC, I was required to learn about the machine I planned on using and given hands-on training. These tactics were necessary to ensure proper and safe use of the equipment. I was assisted during this process by James Brown and Daniel Peterson. I spent many hours working at the IDC while being closely supervised. I was able to complete the speaker housing with adequate time to complete the remaining portions of the project.

The final phase of constructing the dodecahedron speaker included mounting the speakers to the housing, soldering the speaker wires to connectors, and populating the PC board with the appropriate components. There were a few issues I encountered during this phase such as proper pin placement on the connectors. I realized this soon after I

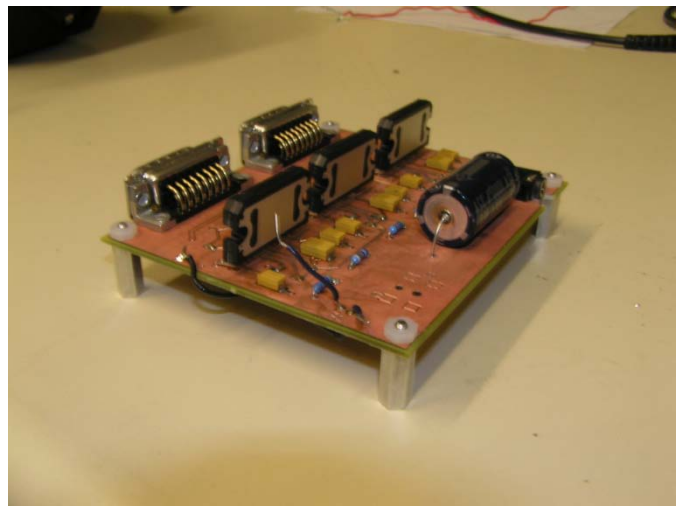


Figure 11: Populated pc board.

discovered that the footprint in the PC board layout was backwards (a common mistake) and required me to re-label the placement of the speaker wires. There was also an issue with the PC board itself that required troubleshooting. After probing with a multi-meter, it became apparent that there was a short circuit between the power & ground plane on the PC board which was causing the problem. Using a pair of fine nosed tweezers, I cleaned out the clearances between the tracing which solved the problem. The next phase of the project will be to characterize the performance of the dodecahedron speakers, but unfortunately due to time constraints, I did not have an opportunity to start this process.

Experience Gained:

My goal upon entering my 2nd working co-op tour at NASA was to gain hands on electrical engineering experience. The experience I gained here during this tour was definitely hands on and I also gained experience with many things I had little to no previous experience with. Working within the Avionic Systems Division at JSC has taught me many workplace and fundamental engineering lessons.



Figure 12: Completed dodecahedron speaker.

One of my primary objectives entering this tour was to gain experience with programming. I am more than satisfied with the programming knowledge I gained during this tour. Having an opportunity to debug the voice recognition program was a great opportunity to develop software debugging experience as well as knowledge of the C programming language. By modifying the existing code, I grew more confident in my abilities to program and hope to continue gaining more experience in this area.

I was also presented with an opportunity to become familiar with NI LabView Software and NI Vision Software. I wasn't able to make as much progress with using the software due to issues with procurement, however just gaining a working knowledge of the LabView

environment and interface was great. I would like to learn more about how it can be utilized in different working areas.

Acquiring experience with soldering was both challenging and fun. What made this even more valuable was that I had never learned proper techniques while soldering and discovered that what I had been doing was not very effective. My branch management provided me with practice kits to learn how to solder better. These proved to be very helpful and helped a great deal when soldering the dodecahedron's PC board. I also had never used a solder wick before and learned how useful it can be to remove solder. Soldering was a skill that I thought I had a sufficient amount of working knowledge prior to arriving here for my 2nd tour, but I am extremely pleased to say that I have greatly advanced my previous knowledge.



Figure 13: Soldering components to pc board.

Working with power tools was actually an unexpected opportunity that presented itself during this tour. Receiving the proper training before using the equipment provided practical experience that I can take with me even away from the working environment. I had a chance to use power tools that I'd never used before and also grew comfortable using them.

The most rewarding experience I gained from this tour was the amplifier circuit design as well as PC board design. Being an electrical engineering major, it is invaluable to work with any circuit design process. This working tour provided a wealth of experience with the circuit design

process and was very much like completing an elongated lab course at school. It was also surprising to actually be able to finish a working model of a PC board before having to return to school. I am confident that I now have sufficient experience working with PC board layout software to complete smaller and less complex designs. Also it was great to actually have problems and difficulties with the amplifier circuit and PC board, because without them I would not have had an opportunity to develop good troubleshooting techniques. I really hope to be able to incorporate some of this experience into my senior design course.

Personal Assessment of Experience:

Completing my 2nd tour at JSC actually exceeded all of my personal expectations. I had an opportunity to work in a lab more often than my last tour which provided me the great hands on experience that I sought out. I must also add that without the guidance and mentoring I received from the experts around me, I would not have been able to accomplish everything that I did. Any equipment, component, or guidance I needed was provided at a moment's notice.

Future:

The co-op program at JSC requires technical co-op students complete 2 semesters and 1 summer of work. I have now completed 2 semesters and only have the summer of



Figure 14: JSC sign as seen from NASA Rd. 1.

2012 tour remaining. This tour will also be in the EV3 Branch. This current tour was a great supplement to what I gained from my previous tour and I plan to continue with what I've learned

both at home and at school. I managed to gain experience with many different things which will only help out with the different projects I plan on working on myself. I plan on graduating in May 2013, and upon graduating I hope to be offered a full-time position as an electrical engineer at JSC. It will take hard work, however I am looking forward to the challenge.



Figure 15: Pictured with dodecahedron speaker after delivering exit presentation to Division Management.